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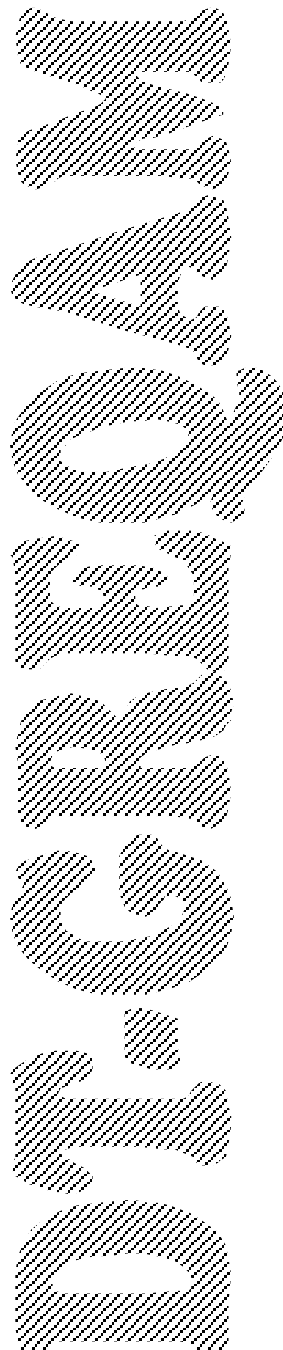
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EDUCATION, CORRUPTION AND THE NATURAL RESOURCE CURSE

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Education, Corruption and the Natural Resource Curse *

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Abstract: The empirical evidence on the determinants of growth across countries has found that growth is lower when natural resources are abundant, corruption widespread and educational attainment low. An extensive literature has examined the way in which these three variables can impact growth, but has tended to address them separately. In this paper we argue that corruption and education are interrelated and that both crucially depend on a country's endowment of natural resources. The key element is the fact that resources affect the relative returns to investing in human and in political capital, and, through these investments, output levels and growth. In this context, inequality plays a key role both as a determinant of the possible equilibria of the economy and as an outcome of the growth process.

JEL classification numbers: O11,O13, O15.

Key words: natural resources, corruption, human capital, growth, inequality.

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1. Introduction

The last two decades have witnessed a revival of interest in the theory and empirics of economic growth. One of the key questions has been to try to understand what prevents growth and economic development, leaving countries locked in a poverty trap. The empirical literature has identified three factors that seem to be systematically correlated with poor economic performance: low educational attainment in the population, widespread corruption, and abundant natural resources.¹ At the same time, a number of empirical studies have shown that these three factors are also interrelated. Glaser et al. (2004) obtain a negative correlation between education and corruption, Sala-i-Martin and Subramanian (2003) find that natural resources tend to reduce a country's institutional quality, while Gylfason (2001) shows that in countries where natural resources are abundant educational attainment tends to be low.

Surprisingly, the theoretical literature has generally considered these three factors separately, or at best in pairs. On the one hand, a number of authors have addressed how corruption and education are jointly determined and their impact on output levels; see Ehrlich and Lui (1999), de la Croix and Delavallade (2008) and Eicher, García-Peñalosa and van Ypersele (2008). On the other, a growing literature has shown that the abundance of natural resources can result in poor institutions which lead to rent-seeking, political mismanagement, or conflict across population groups, with disastrous consequences for growth; see Baland and François (2000), Caselli (2006), Hodler (2006), Robinson, Torvik and Verdier (2006). In this paper we combine these two strands of the literature and argue that natural resources affect *both* education and corruption, implying the co-movements between these three variables observed in the data.

We develop an endogenous growth model with unskilled individuals that can work in the industrial or in the natural resource sector, and skilled agents that work in the industrial sector only. There are two key assumptions in our analysis. The first one is that it is easier for the political class to appropriate the rents stemming from natural resource extraction than from other types of activity. Natural resources are generally owned by the

¹ See Barro (1991) and Mankiw, Romer and Weil (1992) on education, Mauro (1995), Tanzi and Davoodi (2002), and Méndez and Sepúlveda (2006) on corruption, and Sachs and Warner (1999), Bravo-Ortega and De Gregorio (2005), Leite and Weideman (2002), and Isham, Woolcock, Pritchett and Busby (2005) on natural resources and growth.

state and this gives rise to poorly defined property rights which enable the appropriation of rents. In our model we take this idea to the extreme and assume that while the industrial sector is immune to rent seeking, the rents generated by the resource sector can be appropriated by those who invest in political capital. A larger endowment of resources hence increases potential rents and thus the incentives to invest in political capital. The second central element in our analysis is the trade-off between investing in human capital or in political capital examined by Ehrlich and Lui (1999). Skilled individuals can devote a fraction of their time endowment to accumulating human capital or to accumulating political capital. The more others invest in human capital, the higher the return from this investment is for an individual.

This complementarity between human capital investments across individuals gives rise to multiple equilibria. The economy may exhibit a high-growth equilibrium, with no corruption, high human capital investments and fast growth; a low-growth equilibrium with investments in the two types of capital and a low growth rate; or a poverty trap where skilled individuals devote all their time to acquiring political capital, so that there is no industrial production, no human capital accumulation and no growth. The level of natural resources is the crucial parameter determining which of these equilibria exist. For low levels of resources only the high-growth equilibrium exists, while for high levels the poverty trap is the unique outcome. Intermediate resource endowments imply the coexistence of the high-growth equilibrium and one of the other two.

Our model extends the analysis of Ehrlich and Lui (1999) by introducing natural resources and heterogeneity across agents, with important implications. In their model, a growth equilibrium and a poverty trap coexist for all parameter values, implying that which equilibrium prevails is a question only of coordination. This makes policy recommendations particularly difficult as the only way of escaping the poverty trap is for agents to coordinate on the good equilibrium, and it is unclear how policy makers can do so. In our analysis, multiple equilibria appear when resources are larger than a certain threshold, with the threshold being endogenously determined by model parameters. Policies that affect these parameters can then switch the economy to a different equilibrium. A key parameter is the degree of inequality in access to human and political

capital. In particular, the larger the fraction of the population that can invest in political capital, the smaller the payoff to rent-seeking is, which increases the range of values of natural resources for which the high-growth equilibrium is unique. In other words, policies that increase access to the political system can have a major effect on economic performance.

The paper adds to the literature trying to understand why is it that the abundance of natural resources tends to be associated with poor economic performance, the so-called “resource curse”. The argument initially proposed was that natural resources resulted in a Dutch disease,² but more recent work has emphasized how resources result in poor governance and bad institutions. Both Caselli (2006) and Robinson, Torvik and Verdier (2006) maintain that because abundant resources raise the payoff to being in power, incumbent politicians will attempt to remain in power through inefficient redistribution or by reducing productive expenditures in favour of those that increase electoral success. Hodler (2006) explores the idea that the presence of resources causes fighting amongst rival groups in order to appropriate the rents from natural resources. Baland and François (2000) is closely related to our paper in that it considers how natural resources affect the allocation of individuals to rent-seeking or to entrepreneurial activities. Their aim is to show that, since there are multiple equilibria, a resource boom may increase or reduce rent-seeking and output depending on the initial equilibrium, a result we also obtain. Their model is, however, static and considers homogeneous agents. As a result it cannot derive any implications concerning growth or inequality.

In contrast to this literature, our analysis gives a prominent role to human capital. The idea that resources affect human capital accumulation has been explored by Gylfason, Herbertsson and Zoega (1999). Their model is based on a Dutch disease mechanism that affects the price of exports produced with skilled labour and hence output in this sector. A learning-by-doing externality implies that the reduction in output in the skilled sector will in turn affect human capital accumulation. There are a number of differences with our approach. First, given the lack of empirical evidence supporting the Dutch disease mechanism, we do not consider it. Second, we use a concept of human

² Corden and Neary (1992) proposed this argument, but empirical evidence against it is provided by Sachs and Warner (1999), amongst others.

capital accumulation –formal education- that captures more closely the measures used in empirical analyses than learning-by-doing. Third, Gylfason, et al. do not consider rent-seeking nor allow for agent heterogeneity.

The paper is organized as follows. The next section presents the model. We solve it in section 3, characterizing the three possible equilibria and deriving the natural resource thresholds. Section 4 examines the comparative statics of the model, while the last section concludes.

2. Model assumptions

2.1. Technologies

We consider a two-sector endogenous growth model. The first sector consists of the extraction of natural resources, while the second one produces a manufactured good. There exist two types of agents: skilled and unskilled. The population is normalized to one, and there are n skilled workers and $1-n$ unskilled workers. The manufacturing sector employs both types of labour, while the natural resource sector employs only unskilled workers. Unskilled labour can move costlessly between the two sectors. The share of unskilled labour used in the industrial sector is denoted l_{St} , while l_{Rt} denotes the fraction of labour in the natural resource sector.

The engine of growth is the accumulation of human capital by skilled agents. Investment in human capital requires time. Skilled agents have a time endowment of 1 each period, which can be alternatively used to accumulate human capital, H_t , to accumulate political capital (denoted by Q_t), or to produce output. Let h_t denote the amount of time spent accumulating human capital and q_t that spent accumulating political capital, so that $1 - h_t - q_t$ is time spent at work. The stock of human (political) capital of an individual at time $t+1$ is a function on his stock of human (political) capital at t and of the time devoted to accumulation. They are, respectively, given by

$$H_{t+1} = AH_t h_t \quad (1)$$

$$Q_{t+1} = BQ_t q_t \quad (2)$$

where A and B are positive constants. We suppose that unskilled individuals cannot accumulate neither human nor political capital

There is no physical capital in the economy, hence there are three inputs: the two types of labour and natural resources. The manufacturing technology uses unskilled labour and human capital, with output in this sector being produced according to a constant returns technology of the form

$$Y_{St} = [nH_t(1 - h_t - q_t)]^\alpha l_{St}^{1-\alpha}, \quad (3)$$

where $0 < \alpha < 1$. We further suppose that the productivity of the skilled is sufficiently large, specifically that $\alpha > n$, which, as we will see, ensures that the wage of the unskilled is lower than that of the skilled.

Output in the natural resource sector depends on the level of unskilled employment and the stock of natural resources, R , which is given and constant over time.³ We suppose that output in this sector is also given by a constant returns technology of the form

$$Y_{Rt} = a_t R^\alpha l_{Rt}^{1-\alpha} \quad (4)$$

where a_t is the level of technology in the resource sector at time t . This sector benefits from an externality arising from the human capital accumulated by skilled workers. In particular, we assume that $a_t = aH_t^\alpha$, implying that $Y_{Rt} = aH_t^\alpha R^\alpha l_{Rt}^{1-\alpha}$. That is, although the natural resource sector does not use the factor that can be accumulated (human capital) production in this sector grows with human capital. This technological externality is crucial for the resource sector not to disappear in the long run. It can be due to several effects. For example, if we included infrastructure à la Barro (1990), and this infrastructure were financed through income taxation, higher levels of human capital would increase tax revenue and hence expenditure in infrastructure, which would in turn raise productivity in the resource sector.

2.2. Rents and political behaviour

The two sectors are competitive and workers are paid their marginal product. In the manufacturing sector, this implies that output is exhausted by the payment of wages.

³ For simplicity, we assume there is no depletion of natural resources, a reasonable assumption in the medium-term. Note that depletion would tend to make the resource sector less productive, and the overall effect on the allocation of unskilled labour would then depend on the relative strengths of depletion and the technological externality.

However, in the natural resource sector, there is a rent, given by αY_R . We suppose that natural resources are publicly owned, hence firms exploiting them pay the government the resulting rents.

The way in which this revenue is used depends on whether or not there is corruption. If there is no investment in political capital (no corruption) the government will use the revenue to make lump-sum transfers to all individuals. Each individual – whether skilled or unskilled- will then get a transfer of αY_R from the government.⁴ If there is investment in political capital (corruption), skilled individuals will appropriate the whole revenue from the natural resource sector net of the wage paid to the unskilled. We suppose that the revenue from the natural resource sector is distributed among the skilled according to the size of each individual's political capital relative to the average political capital stock of the society, Q_t^* , as in Ehrlich and Lui (1999). We can then express the total income of a corrupt individual as

$$y_{ct} = \alpha \frac{Y_{St}}{n} + \alpha \frac{Y_{Rt}}{n} \left(1 + \ln \frac{Q_t}{Q_t^*} \right) \quad (5)$$

where the first term is the income he gets from working in the manufacturing sector and the second captures the rents from corruption.

We further suppose that, at each period, there is a monetary cost associated to being corrupt. The cost of taking part in corruption activities includes the monetary costs of political participation, as well as direct expenses such as bribes or the administrative costs of concealing income. It can also be interpreted as the expected loss or fine incurred by the individual if detected and punished. We can think of this cost as being directly related to the quality of institutions, with better institutions increasing the cost of concealing income and/or increasing the penalty when caught. The cost is assumed to be proportional to the total revenue of the individual, and is given by zy_{ct} , where $0 < z < 1$.⁵

⁴ Examples of this are the Fund of the Petroleum of Norway and the Alaska Permanent Fund.

⁵ An alternative assumption would have been to make the cost proportional only to corruption rents. This would not have made any qualitative difference to our results, although the derivations would be more cumbersome.

2.3. Households

We assume that agents are infinitely-lived and maximize the following utility function:

$$U = \sum_{t=1}^{\infty} \beta^{t-1} \log c_t \quad (6)$$

where $\beta < 1$ is the discount factor. For the unskilled, income is given by the unskilled wage and, if there is no corruption, government transfers. For the skilled, it is equal to their total income net of the monetary cost of being corrupt.

Let ϕ be an indicator function such that:

$$\phi(q) = \begin{cases} 0 & \text{if } q = 0 \\ 1 & \text{if } q > 0 \end{cases}$$

Since there is no physical capital, all agents consume all their income at each period in time. We can then express the consumption of a skilled individual as

$$c_{st} = \alpha \frac{Y_{St}}{n} + \phi \left(\alpha \frac{Y_{Rt}}{n} \left(1 + \ln \frac{Q_t}{Q_t^*} \right) - z y_{ct} \right) + (1 - \phi) \alpha Y_{Rt}. \quad (7)$$

Since all skilled agents are identical, in equilibrium $Q_t^* = Q_t$. Using this expression and substituting (5) in (7) we obtain the level of consumption of a skilled individual at time t ,

$$c_{st} = \alpha \left(\frac{1 - \phi z}{n} Y_{St} + \left(1 - \phi + \frac{(1 - z)\phi}{n} \right) Y_{Rt} \right), \quad (7')$$

which clearly depends on whether or not there is corruption. Unskilled consumption is, in turn, given by $c_{ut} = (1 - \alpha) Y_{Rt} / l_{Rt} + (1 - \phi) \alpha Y_{Rt}$, where the first term is the wage received by the unskilled and the second the (possible) redistribution.

3. A Dynamic Model of Corruption

3.1. Labour market equilibrium

There are two equilibrium allocations in the model. On the one hand, unskilled workers decide whether to work in the manufacturing or in the resource sector. The allocation across the two sectors will yield the static allocation condition that determines output for a given stock of human capital. On the other, skilled workers decide how to allocate their time between the three possible activities: production, human capital investment,

and the accumulation of political capital. This dynamic allocation will determine the rate of growth of human capital and hence future output.

The mobility of unskilled workers across the two sectors of the economy implies the equality of the unskilled wage in the manufacturing and natural resource sectors. Together with the market clearing condition, $l_s + l_r = 1 - n$, this yields

$$l_{Rt} = \frac{(1-n)a^{1/\alpha}R}{a^{1/\alpha}R + n(1-h_t - q_t)} \quad (8a)$$

$$l_{St} = \frac{n(1-n)(1-h_t - q_t)}{(1-n)a^{1/\alpha}R + n(1-h_t - q_t)} \quad (8b)$$

Clearly, $\partial l_{Rt} / \partial q_t > 0$ and $\partial l_{St} / \partial q_t < 0$. Greater investment in political capital reduces the time that skilled individuals spend working in the industrial sector. This lowers the productivity of the unskilled in manufacturing and induces a flow of unskilled workers from this sector to the natural resource sector. That is, an increase in the time spent accumulating political capital reduces the size of the manufacturing sector and increases that of the natural resource sector.

3.2. The decision to accumulate political capital

A skilled individual will invest in political capital whenever the rents that he can capture through political power are greater than the costs associated to political participation, taking as given the actions of other skilled individuals. That is, $q > 0$ if and only if $\alpha Y_{Rt} / n > zy_{ct}$. Substituting for the production functions and using (8) we find that the agent accumulates political capital if and only if

$$R > \hat{R}(h_t, q_t) \equiv \frac{z}{1-z} n(1-h_t - q_t) a^{-1/\alpha}. \quad (9)$$

This expression implies that the individual is willing to invest in political capital only if natural resources are abundant, that is, if they are above a threshold level \hat{R} . We can immediately see that the higher the cost of political participation, z , the higher is the natural resource threshold required for individuals to chose to be corrupt. Furthermore, \hat{R} is also a function of h and q . The reason for this is that the output of the natural resource sector, and hence the rents obtained by corrupt individuals, depend on the level of

unskilled employment in the sector. Lower values of both h and q increase the time devoted by skilled individuals to production and thus the marginal product of unskilled labour in the manufacturing sector, reducing employment and hence rents in the resource sector for a given level of R .

The allocation of time across activities is, however, endogenous and hence we need to evaluate the threshold once we have determined the investments in human and political capital. As we will see, this dependence of the threshold level of resources on agents' decisions will give rise to multiple equilibria.

3.3. The no-corruption (high-growth) equilibrium

We start by considering the high growth equilibrium, which is defined as an equilibrium in which there are no incentives to accumulate political capital, i.e. $q = 0$. As we have seen, this will occur whenever $R \leq \hat{R}(h_t, q_t)$. Setting $\phi = 0$ in equation (7') we can express the consumption of skilled individuals as

$$c_{st} = \alpha \left(\frac{Y_{St}}{n} + Y_{Rt} \right). \quad (10)$$

The maximization problem faced by a skilled individual is

$$\begin{aligned} \max_{c, h} \quad & U = \sum_{t=1}^{\infty} \beta^{t-1} \log c_{st} \\ \text{s.t.} \quad & H_{t+1} = AH_t h_t \\ & c_{st} = \alpha \left(n^{\alpha-1} H_t^{\alpha} (1-h_t)^{\alpha} l_{St}^{1-\alpha} + a_t R^{\alpha} l_{Rt}^{1-\alpha} \right) \end{aligned}$$

The first order conditions together with equations (8) yields optimal consumption growth,

$$\frac{c_{st+1}}{c_{st}} = \beta A \left(\frac{H_{t+1}}{H_t} \right)^{\alpha-1} \left(\frac{a^{1/\alpha} R + n(1-h_t)}{a^{1/\alpha} R + n(1-h_{t+1})} \right)^{1-\alpha}. \quad (11)$$

From equation (10), and noting that in steady state $h_{t+1} = h_t = h_h$ and l_{St} and l_{Rt} are constant, we can write steady-state consumption growth as $c_{st+1}/c_{st} = (1+g)^{\alpha}$, where $g \equiv H_{t+1}/H_t - 1$ is the rate of growth of human capital. Substituting this expression in (11), we obtain that in the high-growth equilibrium the time devoted to human capital investment is

$$h_h = \beta, \quad (12a)$$

and, from (1), human capital accumulation is given by

$$1 + g_h = \beta A. \quad (12b)$$

It is then straightforward to show from the production function that the steady state rates of growth of output and consumption in the high-growth equilibrium are equal to $\alpha \ln \beta A$. As in Lucas (1988), the more patient the individual and the more productive the human capital technology, the faster the rate of growth is.

For high-growth to be an equilibrium, natural resources must be below the threshold level $\hat{R}(h_h, q_h)$. Evaluating this threshold at the equilibrium time allocation just obtained we have

$$\bar{R} \equiv \hat{R}(\beta, 0) = \frac{z}{1-z} a^{-1/\alpha} n(1-\beta). \quad (13)$$

Then, the high-growth equilibrium exists for all levels of natural resources below \bar{R} , and does not exist for $R > \bar{R}$.

3.4. Equilibria with corruption

The incentive to invest in political capital appears when the level of natural resources is sufficiently high for revenues from the appropriation of rents to be greater than the private cost of corruption. That is, if $R > \hat{R}(h_t, q_t)$ then $q > 0, h \geq 0$. When there is corruption, the consumption of the skilled will be

$$c_{st} = \frac{\alpha(1-z)}{n} \left[Y_{St} + Y_{Rt} \left(1 + \ln \frac{Q_t}{Q_t^*} \right) \right]. \quad (14)$$

The maximization problem faced by the individual is then

$$\begin{aligned} \max_{c, h, q} \quad & U = \sum_{t=1}^{\infty} \beta^{t-1} \log c_{st} \\ \text{s.t.} \quad & H_{t+1} = A H_t h_t \\ & Q_{t+1} = B Q_t q_t \\ & c_{st} = \frac{\alpha(1-z)}{n} \left[n^\alpha H_t^\alpha (1-h_t-q_t)^\alpha l_{St}^{1-\alpha} + a_t R^\alpha l_{Rt}^{1-\alpha} \left(1 + \ln \frac{Q_t}{Q_t^*} \right) \right]. \end{aligned}$$

The solution to this problem is derived in the appendix. Solving the control problem we find the following first order conditions with respect to h_t and q_t ,

$$\frac{c_{st+1}}{c_{st}} = \beta A \left(\frac{H_{t+1}}{H_t} \right)^{\alpha-1} \left(\frac{a^{1/\alpha} R + n(1-h_t-q_t)}{a^{1/\alpha} R + n(1-h_{t+1}-q_{t+1})} \right)^{1-\alpha} (1-q_{t+1}), \quad (15a)$$

$$\frac{c_{st+1}}{c_{st}} = \beta \left(\frac{H_{t+1}}{H_t} \right)^{\alpha} \left(\frac{a^{1/\alpha} R + n(1-h_t-q_t)}{a^{1/\alpha} R + n(1-h_{t+1}-q_{t+1})} \right)^{1-\alpha} \left[\frac{q_{t+1}}{q_t} + \frac{a^{1/\alpha}}{\alpha n} \frac{R}{q_t} \right], \quad (15b)$$

which equate the ratio of consumption in two periods to the ratio of the returns to investment in human capital and in political capital, respectively. From (14), and using the fact that since all skilled agents are identical $Q_t = Q_t^*$, we can express the consumption ratio as

$$\frac{c_{st+1}}{c_{st}} = \left(\frac{H_{t+1}}{H_t} \right)^{\alpha} \frac{n^{\alpha} (1-h_{t+1}-q_{t+1})^{\alpha} l_{St+1}^{1-\alpha} + a R^{\alpha} l_{Rt+1}^{1-\alpha}}{n^{\alpha} (1-h_t-q_t)^{\alpha} l_{St}^{1-\alpha} + a R^{\alpha} l_{Rt}^{1-\alpha}}. \quad (16)$$

Equations (15a), (15b) and (16) together determine the investment in human capital, the investment in political capital, and the time path of consumption.

In steady state $h_{t+1} = h_t = h_t^*$, and $q_{t+1} = q_t = q_t^*$. Equation (16) then implies that the steady state rate of growth of consumption is given, as before, by $c_{st+1}/c_{st} = (1+g)^{\alpha}$. We can then use this expression to substitute into (15) and obtain the equilibrium values of q and h . The interior solution to the individual's maximization problem can be expressed as

$$q = \frac{R}{R^*}, \quad (17a)$$

$$h = \beta \left(1 - \frac{R}{R^*} \right), \quad (17b)$$

where $R^* \equiv (1-\beta)\alpha n a^{-1/\alpha} / \beta$. Depending on the value of R , we can have an interior or a corner solution, which give rise to two possible equilibria, a low-growth equilibrium and a no-growth equilibrium. We examine these in turns.

3.4.1. The low-growth equilibrium

The economy will be in a low-growth equilibrium when there are positive investments in both human and political capital in every period. The low-growth equilibrium investments in political and human capital are

$$q_l = \frac{a^{1/\alpha}}{\alpha n} \frac{\beta}{1-\beta} R, \quad (18a)$$

$$h_l = \beta \left(1 - \frac{a^{1/\alpha}}{\alpha n} \frac{\beta}{1-\beta} R \right), \quad (18b)$$

while the rate of growth of human capital is given by

$$1 + g_l = \beta A \left(1 - \frac{a^{1/\alpha}}{\alpha n} \frac{\beta}{1-\beta} R \right). \quad (18c)$$

Clearly, $\partial q / \partial R > 0$ and $\partial h / \partial R < 0$. A greater endowment of natural resources makes rent-seeking behaviour more profitable and hence increases q . This in turn results in a reduction of the investment in human capital, which reduces growth. We can also see that the greater the number of skilled, n , the greater (smaller) the investment in human (political) capital, and the more patient agents are, the greater will be the investment in the political capital. The effect of β on human capital investment is ambiguous, as greater patience tends to increase it but more investment in political capital tends to reduce it.

For the low-growth equilibrium to exist, two conditions are needed. First, the level of natural resources must be sufficiently high for individuals to invest in political capital. That is $R \geq \underline{R}$ where

$$\underline{R} \equiv \hat{R}(h_l, q_l) = \frac{z\beta R^*}{z\beta + (1-z)\alpha} \quad (19)$$

Second, the level of natural resources must not be so high that individuals invest only in political and not in human capital. That is, $h_l > 0$, which from (17b) requires $R < R^*$. We can express the two conditions for existence of the low growth equilibrium as $\underline{R} < R < R^*$. If $R \geq R^*$, then $h = 0$ and the economy will find itself in a poverty trap which we next examine.

3.4.2. The poverty trap

The economy will fall in a poverty trap when the level of natural resources is so high that the incentive to accumulate political capital eliminates all investment in human capital. To see this note that since investments in the two types of capital are bounded below by zero and above by the time endowment, 1, the solutions to the individual's maximization problem given by (17) imply that for $R \geq R^*$ there is a corner solution of the form

$$q_p = 1, \quad (20a)$$

$$h_p = 0. \quad (20b)$$

This means that in this equilibrium, skilled individuals devote all their time to accumulating political capital and do not accumulate human capital nor spend time in the manufacturing sector. Because there is no investment in human capital, there is no growth, and both consumption and human capital remain constant. That is, $g_p = 0$ and $H_{t+1} = H_t = H_p$. Moreover, there is no manufacturing production as the skilled devote all their time to accumulating political capital.

4. Natural Resource Thresholds and Possible Equilibria

4.1. Equilibrium configurations

In order to understand when each of the equilibria will emerge, we need to consider under which ranges of R each of the three possible equilibria exist. Our results above imply that

- the high-growth equilibrium can exist for all $R \leq \bar{R}$,
- the low-growth equilibrium can exist for all $\underline{R} < R < R^*$,
- the poverty-trap can exist for all $R \geq R^*$.

The relationship between these three thresholds determines the possibility of existence of multiple equilibria. From equations (13) and (19) and the expression for R^* , we can see that \underline{R} will always be smaller than both R^* and \bar{R} . However, the relationship between R^* and \bar{R} will depend on the parameters of the model. In particular, R^* will be greater than \bar{R} if and only if $z < \alpha/(\alpha + \beta)$, i.e. if z is sufficiently small.

Figures 1 and 2 depict the possible equilibria under the two parameter configurations. In both cases, the investment functions in human and political capital present a discontinuities at \underline{R} , and there is an interval where the model exhibits multiple

equilibria. Small endowments of natural resources result in high-growth, human capital investment and no corruption. For intermediate levels of natural resources, multiple equilibria are possible, while for large endowments of natural resources, there is a poverty trap with no growth, no human capital, investment, and high corruption. A key parameter is the cost of political participation, z . Figure 1 presents the case in which $z \leq \alpha/(\alpha + \beta)$. When the cost is low, a high-growth and a low-growth equilibrium coexist for intermediate levels of resources. The case of a high cost, i.e. $z > \alpha/(\alpha + \beta)$ is depicted in figure 2. The range of values of R for which a high-growth equilibrium exists is greater, and as a result, the high- and low-growth equilibria coexist for $\underline{R} < R < R^*$, while the high-growth equilibrium and the poverty trap coexist for $R^* \leq R < \bar{R}$.

These results are the combination of two elements: the interdependence between individual q and the size of rents, and the presence of the fixed cost. The interdependence is due to the fact that the size of corruption rents obtained by one agent depends on the investment in political capital of others. If other skilled individuals spend a large fraction of their time accumulating political capital, their time spent in manufacturing falls. As a result, unskilled labour flows to the natural resource sector increasing output and rents. In the absence of the cost z , this would not be enough to create multiplicity. To see this, note that when $z=0$, $\bar{R} = \underline{R} = 0$, implying that the high-growth equilibrium does not exist, and that there are only two possible configurations: a low-growth equilibrium when resources are below R^* and a poverty trap when resources are above this threshold.⁶ A positive value of z makes the high-growth equilibrium possible. Since there is a fixed cost of corruption, an individual will only acquire political capital if the rents are high enough, i.e. if others are investing sufficiently in political capital. The higher the cost, the greater is the range over which the high-growth equilibrium exists. For $z=1$, $\bar{R} = \infty$ and $\underline{R} = R^*$, implying that the high-growth equilibrium and the poverty trap coexist for the entire range of possible values of R .

⁶ This is the configuration found in Ehrlich and Lui (1999), where there is no equilibrium without corruption.

Figure 1: Equilibria with low z ($z \leq \alpha/(\alpha + \beta)$)

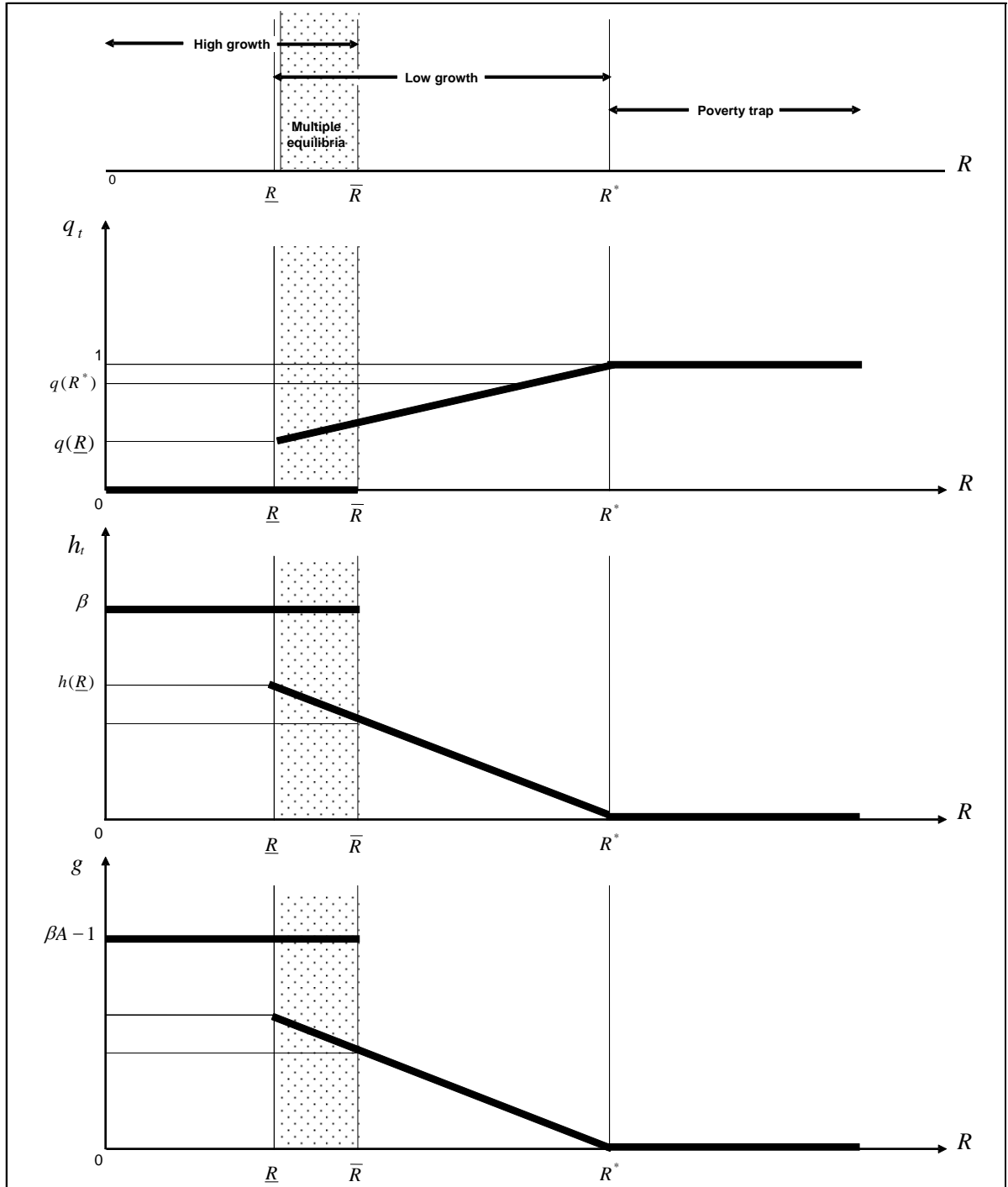
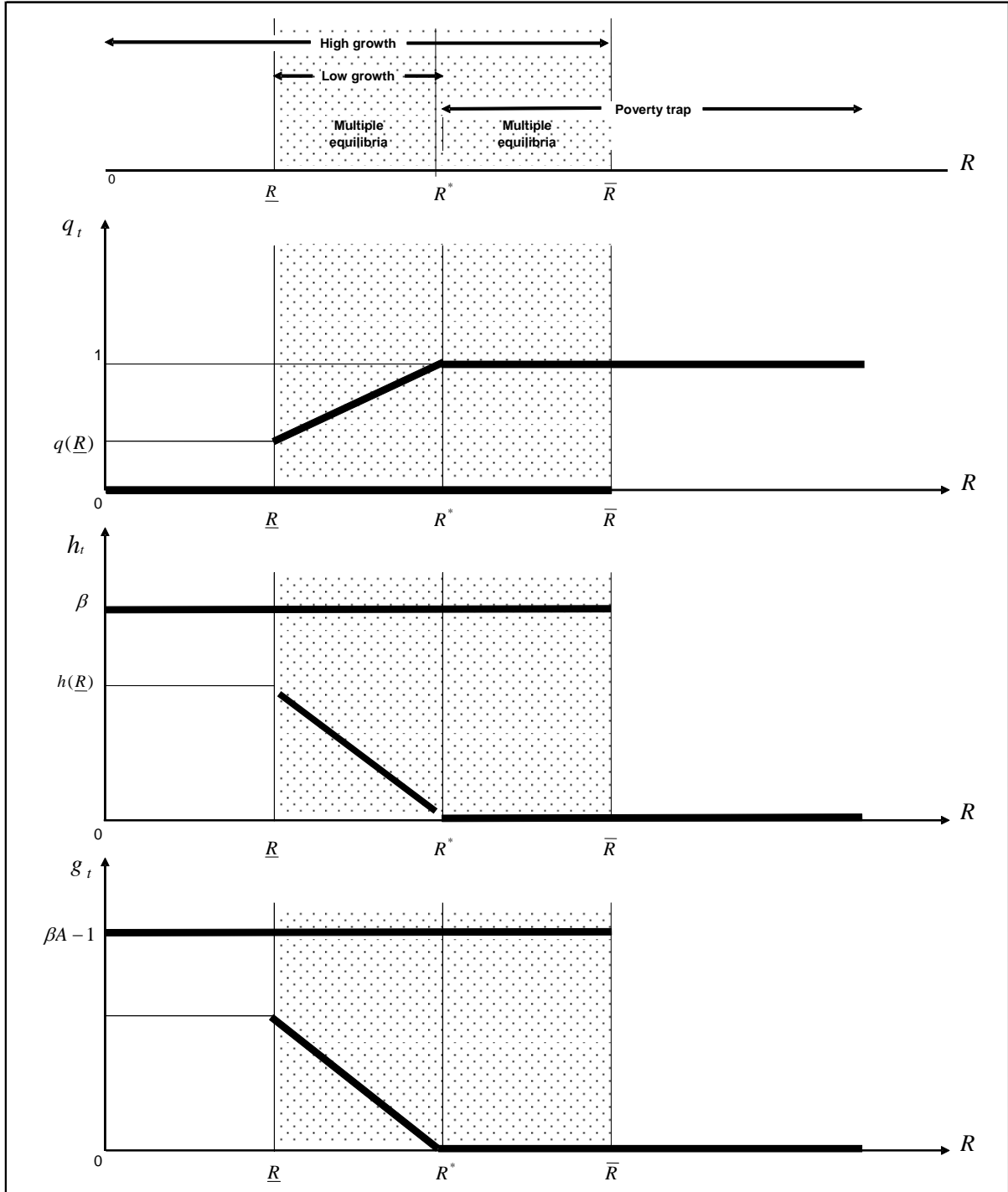


Figure 2: Equilibria with high z ($z > \alpha/(\alpha + \beta)$)



4.2. Comparative statics

We can now compare the features of the three equilibria, which are summarized in Table 1.⁷ Greater human capital accumulation is associated with faster growth and lower levels of corruption. There are also static losses associated with corruption, as the investment in political capital diverts resources away from manufacturing production and reduces aggregate output at any point in time, as can be seen by comparing the output levels reported in the fifth line.

Table 1: Characterisation of the equilibria

	High growth	Low growth	Poverty trap
Natural resources	$R \leq \bar{R}$	$\underline{R} < R < R^*$	$R \geq R^*$
Human capital	$h_h = \beta$	$h_l = \beta \left(1 - \frac{R}{R^*}\right)$	$h_p = 0$
Political capital	$q_h = 0$	$q_l = \frac{R}{R^*}$	$q_p = 1$
Growth of H	$g_h = \beta A - 1$	$g_l = \beta A \left(1 - \frac{R}{R^*}\right) - 1$	$g_p = 0$
Aggregate output	$Y_h = a(1-n)^{1-\alpha} H^\alpha \left(R + \frac{\beta}{\alpha} R^*\right)^\alpha$	$Y_l = a(1-n)^{1-\alpha} H^\alpha \left(R + \frac{\beta}{\alpha} (R^* - R)\right)^\alpha$	$Y_p = a(1-n)^{1-\alpha} H^\alpha R^\alpha$
Inequality	$I_h = \frac{\alpha}{n} \frac{(1-n)(\alpha n R + \beta R^*)}{\alpha(1-\alpha n)R + (1-\alpha)\beta R^*}$	$I_l = \frac{\alpha}{1-\alpha} \frac{1-n}{n} (1-z)$	$I_p = \frac{\alpha}{1-\alpha} \frac{1-n}{n} (1-z)$

Natural resources have two effects: a direct effect on output, given the type of equilibrium, and an impact on the feasible equilibria. As discussed in the previous section, small endowments imply that only the high-growth equilibrium exists, intermediate endowments result in the coexistence of a high-growth and a low-growth/poverty-trap equilibria, while for large endowments the economy will find itself in a poverty trap. The direct effect of resources is, however, ambiguous. Conditional on

⁷ The expressions for inequality presented in Table 1 are derived in section 4.3 below.

being in the high-growth equilibrium, resources are a “blessing”. Total output in this equilibrium is given by $Y_h = a(1-n)^{1-\alpha} H^\alpha (R + \beta R^* / \alpha)^\alpha$ and hence increasing in R , although the growth rate is unaffected by the level of resources. In contrast, in the low-growth equilibrium, a higher value of R increases corruption, reducing human capital accumulation and growth.

A crucial parameter in the analysis is, as we have seen, the cost of engaging in corruption. The value of z does not affect R^* , and hence does not affect the range over which the poverty trap exists. A larger z , however, implies higher threshold levels \underline{R} and \bar{R} , which increase the range over which only the high-growth equilibrium exist ($R \leq \underline{R}$) and that over which it co-exists with other equilibria ($\underline{R} < R \leq \bar{R}$). An immediate implication of the role played by z in determining the possibility of multiple equilibria is that the existence of natural resources in a country does not necessarily lead to a resource curse. If the cost of corruption is sufficiently high, multiple equilibria are possible and consequently abundant resources are compatible with no corruption.

Another implication of the analysis is that the presence of natural resources creates the possibility of leap-frogging. Consider two otherwise identical economies which differ in the level of resources, such that economy A has a low level $R_A < \underline{R}$ and economy B has a large endowment $R_B > R^*$. Economy A is hence in the high-growth equilibrium and has positive growth, while economy B is in a poverty trap and experiences no growth. If B 's endowment is sufficiently large, output will initially be higher in this economy.⁸ However, fast growth in country A will allow the latter to catch-up and eventually surpass the output of country B .

4.3. Inequality

There are two concepts of inequality that we can consider: inequality in access to human and political capital, captured by the parameter n , and income inequality across the two types of agents. Inequality in access is a crucial model parameter. Recall that $R^* \equiv (1-\beta)\alpha n a^{-1/\alpha} / \beta$ and that both \bar{R} and \underline{R} are proportional to R^* . A higher value of

⁸ The precise condition is $R_B - R_A > \beta R^* / \alpha$.

n hence shifts to the right the three thresholds, implying that the range of resources for which the high-growth equilibrium exist is larger (due to the increase in \bar{R}) and the range for which it is the only possible equilibrium is greater (as \underline{R} rises). That is, the larger the fraction of the population that has access to investments in human and political capital, the more likely a high-growth equilibrium is. The intuition for this result is straightforward. Recall that corrupt individuals divide the rents from the sector amongst all the skilled. The larger the size of this group is, the lower the rents per capita are, making it less likely that corruption pays off. That is, more widespread access to political activity reduces the range of natural resources over which corrupt equilibria exist.

Heterogeneity across agents also implies that income levels will differ between the skilled and the unskilled. Moreover, different equilibria may result in different degrees of income inequality. A convenient measure of income inequality is the ratio of the income of the skilled to that of the unskilled, which is given by

$$I = \frac{\frac{\alpha(1-z\phi)}{n}Y_S + \phi \frac{\alpha(1-z)}{n}Y_R + (1-\phi)\alpha Y_R}{\frac{(1-\alpha)Y_S}{I_S} + (1-\phi)\alpha Y_R}. \quad (21)$$

Income inequality in the high-growth equilibrium and in the equilibria with corruption are given, respectively, by

$$I_h = \frac{\alpha}{1-\alpha} \frac{1-n}{n} \frac{\alpha n R + \beta R^*}{\alpha(1-\alpha n)R/(1-\alpha) + \beta R^*}, \quad (22a)$$

$$I_l = I_p = \frac{\alpha}{1-\alpha} \frac{1-n}{n} (1-z). \quad (22b)$$

In both expressions the first term ($\alpha/(1-\alpha)$) captures the relative productivity of skilled and unskilled workers, while the second term $((1-n)/n)$ captures the relative labour supplies, and are standard. A higher relative productivity of the skilled and a lower relative supply will tend to increase income inequality. The additional term in (22b), $(1-$

z), captures the fact that when there is corruption a fraction of the income of the skilled is used to pay for the corruption costs. The higher this cost, the lower income inequality is.⁹

To examine the various elements affecting inequality in the high-growth equilibrium, we can express I_h as

$$I_h = \frac{\alpha}{1-\alpha} \frac{1-n}{n} \frac{a^{1/\alpha} R + (1-\beta)}{\frac{1-\alpha n}{n} \frac{a^{1/\alpha}}{1-\alpha} R + (1-\beta)}. \quad (23)$$

There are two forces affecting inequality in this case. First, in the high-growth equilibrium there is a lump-sum transfer to all agents that tends to reduce inequality. The larger the size of the natural resource sector is, i.e. the larger R , the stronger this effect is. Second, the rate of time preference affects human capital accumulation and hence time spent in production, which in turn impacts on inequality. Differentiating, we have $\partial I_h / \partial \beta < 0$. A higher rate of time preference increases investments in human capital and reduces time spent in production, reducing the labour income of the skilled and hence inequality.

Inequality in the high-growth equilibrium may be greater or lower than in the equilibria with corruption. Inequality will be lower in the high-growth equilibrium if and only if

$$\left(\frac{1-z}{1-\alpha} \frac{1-\alpha n}{n} - 1 \right) \frac{a^{1/\alpha}}{z} R > (1-\beta). \quad (24)$$

There are three forces affecting inequality captured by the parameters R , β , and z . The larger the R the stronger the redistributive effect is and the larger β the lower the wage of the skilled, both of which make it more likely that $I_h < I_l$. The cost of political participation, z , reduces the income of the skilled, and hence inequality, when there is corruption. The larger this cost is, the less likely it is that $I_h < I_l$.

⁹ Note that the last term in both inequality expressions is less than 1 and hence we require restrictions on parameters to ensure that the wage ratios are greater than one. In particular, $I_l > 1$ requires that $z < (\alpha - n) / (\alpha - \alpha n)$, while $I_h > 1$ if and only if $(1-\beta)(\alpha - n)a^{-1/\alpha} / (1-\alpha) > R$.

5. Concluding Comments

A wealth of evidence has documented that slow growth and poverty traps tend to be associated with low educational attainment, widespread corruption, and abundant natural resources. In this paper we have argued that these three aspects are interrelated, and proposed a model in which natural resources affect both corruption and education decisions, which in turn determine growth.

We have considered a two-class economy where the skilled have access to the accumulation of both human and political capital. Corruption takes the form of individual rent-seeking behaviour that appropriates rents from the natural resource sector and which becomes possible due to the accumulation of above-average political capital. Corruption has both static and dynamic costs. Accumulating political capital reduces time spent in production, thus reducing current output, and time spent in education, which reduces growth. In this context multiple equilibria emerge: a high-growth equilibrium with no corruption, a low-growth equilibrium with accumulation of both human and political capital, and a poverty trap with no education investments.

The possible equilibria crucially depend on natural resources. There exist two thresholds such that when resources are below the lower bound only the high-growth equilibrium exist, when they are above the upper threshold only the poverty trap is possible, while multiplicity appears from intermediate ranges. Moreover, these thresholds are endogenous and depend on model parameters. This aspect is crucial for the policy recommendations. Existing models of the resource curse tend to be characterized by multiplicity for all parameter configurations. As a result, switching from one equilibrium to the other requires coordination, something which is difficult to implement by a policy-maker. In contrast, our setup identifies a number of parameters that will increase the range over which a growth equilibrium is unique.

A crucial parameter in the analysis is inequality in access to human and political capital investments, that is, the fraction of the population that is skilled. If this fraction is small, per capital rents from corruption are high, making rent-seeking more likely. If, on the contrary, this fraction is large the consequent reduction in corruption rents will increase the range of resources for which only a high-growth equilibrium exists. As a result, increasing access to the political process by the population can allow a country to

escape from the poverty trap. Interestingly, income inequality need not move together with inequality in access to human capital investments, since the income of the skilled relative to the unskilled may be higher or lower in the poverty-trap than in the high-growth equilibrium.

The possibility of leap-frogging implied by the model can provide an explanation of the different experiences of East Asian and sub-Saharan African economies. In the 1950s the perception among development economists was that the serious problem was faced by East Asia. African countries were resource rich, and natural resources would bring in the revenues needed to trigger growth (Hance, 1956); East Asian economies were uneducated and resource poor, and hence had no way of escaping the poverty trap. Yet, the next few decades witnessed a massive increase in both education and per capita incomes in the Asian economies and stagnation in most African countries (Temple, 1999). Our model suggests that the abundant endowment in natural resources of the latter lead to the accumulation of political capital at the expense of human capital, while scarce resources created the incentives for the former to invest in education and leap-frog the rich African economies.

The key prediction of our model is that the impact of natural resources operates through increased corruption and reduced education. Isham et al. (2005) test the hypothesis that the resource curse operates through weak institutions and find support for it, identifying a significant effect occurring through corruption. Unfortunately, they treat education as an exogenous variable in their system which is strongly correlated with corruption. Gylfason (2001) and Gylfason et al. (1999) provide evidence of a significant negative correlation between the abundance of resources and education. Their results indicate that the resource curse partly operates through this mechanism, although resources have a significant effect on growth even when the human capital variable is included. Further empirical work is needed to assess whether corruption and education are both simultaneously affected by resources and to examine whether accounting for these two mechanisms suffices to explain most of the resource curse.

APPENDIX

In this appendix we derive the solution to the skilled workers' maximization problem.

The maximization problem is

$$\begin{aligned} \max_{c, q, h} \quad & U = \sum_{t=1}^{\infty} \beta^{t-1} \log c_{st} \\ \text{s.t.} \quad & H_{t+1} = AH_t h_t \\ & Q_{t+1} = BQ_t q_t \\ & c_{st} = \frac{\alpha(1-z)}{n} \left[n^\alpha H_t^\alpha (1-h_t-q_t)^\alpha l_{St}^{1-\alpha} + a_t R^\alpha l_{Rt}^{1-\alpha} \left(1 + \ln \frac{Q_t}{Q_t^*} \right) \right]. \end{aligned}$$

The Hamiltonian is

$$H(h_t, q_t, H_t, Q_t, \lambda_{1t+1}, \lambda_{2t+1}, t) = \beta^{t-1} \log c_{st} + \lambda_{1t+1} (AH_t h_t - H_t) + \lambda_{2t+1} (BQ_t q_t - Q_t),$$

which yields the following first-order conditions:

$$\begin{aligned} \beta^{t-1} \frac{1}{c_t} \frac{\partial c_{st}}{\partial h_t} + \lambda_{1t+1} AH_t &= 0, \\ \beta^{t-1} \frac{1}{c_t} \frac{\partial c_{st}}{\partial q_t} + \lambda_{2t+1} BQ_t &= 0, \\ \lambda_{1t+1} - \lambda_{1t} &= - \left[\beta^{t-1} \frac{1}{c_{st}} \frac{\partial c_{st}}{\partial H_t} + \lambda_{1t+1} (Ah_t - 1) \right], \\ \lambda_{2t+1} - \lambda_{2t} &= - \left[\beta^{t-1} \frac{1}{c_{st}} \frac{\partial c_{st}}{\partial Q_t} + \lambda_{2t+1} (Bq_t - 1) \right], \end{aligned}$$

Together with the transversality conditions

$$\lim_{t \rightarrow \infty} \lambda_{1t+1} H_t = 0 \quad \text{and} \quad \lim_{t \rightarrow \infty} \lambda_{2t+1} H_t = 0.$$

We then obtain

$$\begin{aligned} \frac{c_{st+1}}{c_{st}} &= \beta A \left(\frac{H_{t+1}}{H_t} \right)^{\alpha-1} \left(\frac{1-h_{t+1}-q_{t+1}}{1-h_t-q_t} \right)^{\alpha-1} \left(\frac{l_{St+1}}{l_{St}} \right)^{1-\alpha} (1-q_{t+1}) \\ \frac{c_{st+1}}{c_{st}} &= \beta \left(\frac{H_{t+1}}{H_t} \right)^\alpha \left[\frac{q_{t+1}}{q_t} \left(\frac{1-h_{t+1}-q_{t+1}}{1-h_t-q_t} \right)^{\alpha-1} \left(\frac{l_{St+1}}{l_{St}} \right)^{1-\alpha} + \frac{a}{\alpha n^\alpha} \left(\frac{l_{Rt+1}}{l_{St}} \right)^{1-\alpha} \frac{R^\alpha}{q_t} \right] \end{aligned}$$

which yield equations (15) in the text.

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